The influence of previous reproduction on subsequent fertility in multiparous ewes

DR Scobie[1]*, D O'Connell[1], A Noble[1], and AW Greer[2]

[1]*AgResearch Lincoln, Private Bag 4749, Christchurch, 8140;* [2] *Faculty of Agriculture and Life Sciences, P.O. Box 85084, Lincoln University*

**Corresponding author.* Email: Scobie@agresearch.co.nz

Abstract

Adult ewes often lose live weight while lactating, but should regain it prior to the following mating if pasture availability or sheep numbers are managed judiciously. Data from a self-replacing flock of Wiltshire ewes four to nine years of age (n=267) was available for 622 lambing events across a 13-year period. Wiltshires grow little wool and live weight was not complicated by fleece weight. The average number of lambs born was 1.76 per ewe per year during the course of the study. Ewes not rearing a lamb (13.2%), or rearing singles (42.4%), twins (42.4%), or triplets (1.9%), were present at weaning. All ewes were grazed together and when their lambs were weaned, those that did not raise a lamb (67.4 ± 9.7 kg) were heavier than ewes that raised singles (63.0 ± 9.3 kg), twins (59.9 ± 8.5 kg) or triplets (59.7 ± 7.7 kg) ($P<0.001$). Despite this, the previous number of lambs weaned did not influence the number of lambs born in the subsequent year ($P = 0.43$), but was positively associated with ewe liveweight gain between weaning and mating ($P<0.01$). Number of lambs born was positively influenced by ewe live weight at mating up to 65 kg. Reproductive performance was not influenced by the previous year, providing ewes were able to increase live weight between weaning and mating.

Keywords: number of lambs weaned; number of lambs born

Introduction

Literature abounds on the effect of ewe live weight on fertility. Increasing live weight at mating is associated with a greater number of lambs born (Rattray et al. 1980; Thompson et al. 1990). Live weight could be equal for a large skinny ewe and a small fat ewe, so body condition scoring has been used as a rapid-assessment technique to judge fatness of the ewe. A review suggested that maintaining good body condition score of the ewe leads to improved lamb production (Kenyon et al. 2014). Live weight and body condition vary throughout the year due to seasonal changes in nutrition and reproductive activity. Rather than maintaining ewes in good condition year round, it may be more achievable to allow their weight to fluctuate, providing that does not compromise the number of lambs born or the number and weight of lambs weaned.

Without doubt, a ewe that has more lambs contributes more to farm income. However, sustaining high levels of production requires repeated performance. Many investigations have sought genetic improvement in reproduction (e.g., Davis et al. 1987), but commercial sheep farmers have little information on individual ewe genetic worth and little more than assessments of body, teeth and udder condition with which to improve reproduction in the period leading to mating. Once the ewes have been mated, pregnancy scanning to estimate the number of lambs *in utero* can be used to manage ewes with single and multiple pregnancies. However, this occurs after conception, when management largely influences ewe mortality and lamb survival. An indicator of prior performance could improve pre-mating selection and management decisions. Using very large data sets, Amer et al. (2007) found that a large litter tended to be followed by a smaller litter, which suggests there may be a consequence of previous lactation on the subsequent lambing.

A dataset was available for a flock of New Zealand Wiltshire sheep maintained on an irrigated farm in Canterbury. The relatively wool-free Wiltshire is particularly interesting in that live weight of the ewe at weaning of her lambs and at the following mating is not complicated by the growth of fleece. The hypothesis tested here was whether reproductive performance the previous year could influence mating weight and, therefore, the subsequent number of lambs born. Further to this, whether loss of live weight during reproduction might affect the total weight of lamb weaned.

Materials and methods

Records of live weight of ewes and lambs at weaning, and ewes at mating were available for a self-replacing flock of Wiltshire sheep. The flock was described by O'Connell et al. (2012), and their production relative to Perendale sheep on the same farm is outlined elsewhere (Sumner et al. 2012). Ewe live weight was recorded at mating and weaning each year, with lambs tagged at birth and matched to their dam. Weaning weight of lambs was recorded to allow calculation of total weight of lamb weaned per ewe. The number of ewes in each age group in the flock is shown in Figure 1, along with their average live weight at mating. Average live weight increased in two- and three-year old ewes, and preliminary analysis supported a strong relationship between live weight and the number of lambs born for these age groups. Since two- and three-year old ewes dominated the flock, and they continued to increase in live weight during pregnancy, lactation and following weaning of their offspring, the outcome of mating in the whole flock was biased by their growth. Very few ewes survived in the flock beyond nine years of age and live weight declined in those that did. Excluding the data for ewes three year old or younger, and ewes older than nine years provided a group of mixed-age ewes (n = 267) for whom average live weight was relatively stable between four and nine years old (Fig 1). Given the decline in number of older ewes, most records came from four and five year old ewes, but records from an ever decreasing number of ewes were utilised up to nine years of age. These ewes gave birth to 1098 lambs, from 622 lambing events and weaned 828 lambs across 13 years on one farm. Average lambing percentage at birth was 176% and weaning percentage 133%.

Analysis

General linear models were fitted to mating live weight and ewe live weight when lambs were weaned, number of lambs born in year 2 and number of lambs weaned in year 1, and total weight of lambs weaned and ewe weight change during pregnancy and lactation. Year 1 was defined as the year of pregnancy and lactation that could have had some effect on weaning weight of the ewe and her progeny at the end of that reproduction period, and therefore influence mating weight and number of lambs born in the following year (year 2). Some individual animals appear in the data more than once, but this number was small and they did not affect the results substantively. Loess smooth curves were fitted to the number of lambs born and number of lambs weaned versus the live weight at mating carried out in R (R Core Team 2015). Live weight and performance of ewes in year 1 and 2 relative to the number of lambs was analysed with a one-way ANOVA (MINITAB®, version 16, 2010, Minitab Inc, USA).

Results

Ewe performance relative to number of lambs weaned in year 1 and number of lambs born in year 2 is given in Table 1. Ewe live weight at weaning declined with increasing number of lambs weaned ($P<0.01$). This effect persisted until mating in year 2, being only partially compensated for by the greater live weight gain from weaning to mating in single- and twin-bearing ewes. Live weight of ewes at mating in year 2 was strongly associated with their previous live weight at weaning in year 1 ($R^2 = 0.59$, $P<0.001$). In contrast, there was a weaker correlation between ewe live weight at weaning in year 1 and year 2 ($R^2 = 0.24$). Total weight of lamb weaned increased with greater number of lambs weaned ($P<0.01$). Total weight of lamb weaned was further influenced within rearing rank by the ewe weight loss from mating to weaning (Figure 2), which became more pronounced as the number of lambs weaned increased ($P<0.01$). The slope of the line for one lamb weaned was -0.1326, which was significantly different from 0 ($P=0.016$), and the slope for the two lambs weaned was -0.3314 and these two were significantly different ($P=0.013$). The slope of the line for 3 lambs was -0.6552, which was not significantly different from the slope for one lamb due to the small sample size.

Overall, there was a tendency for ewes that weaned more lambs in year 1 to have more lambs born in year 2 ($P=0.06$). The change in the population distribution relative to weaning rank in year 1 and birth rank in year 2 is given in Figure 3. There were only six records of triplets weaned in year 1, with all of these giving birth to twins in year 2. For the remaining weaning ranks, the proportion of records relative to birth rank was relatively similar with 56%, 62% and 61% of ewes that weaned 0, 1 or 2 lambs in year 1, respectively, giving birth to twins in year 2. Similarly, 30%, 29% and 22% of ewes weaning 0, 1 or 2 lambs in year 1, respectively, gave birth to singles in year 2. The number of lambs born in year 2 was not influenced by the weight of lamb weaned in year 1 ($P=0.11$) or ewe live weight at weaning in year 1 ($P=0.43$). In contrast, the number of lambs born increased with greater live weight at mating ($P<0.01$) which was associated with a greater live weight gain between weaning and mating ($P<0.01$).

Table 1 Characteristics of ewes relative to the number of lambs weaned in year 1 and number of lambs born in year 2. The P values for the main effect (Main effect) have been adjusted for the multiple comparisons with a Tukey adjustment.

	Number of lambs weaned year 1				
	0	1	2	3	Main effect
	n=77	n=294	n=245	n=6	
Total weight of lamb weaned Y1 (kg)	n.a.	30.2 ± 0.29^{a}	52.5 ± 0.47^{b}	67.1 ± 0.37^{c}	P<0.01
LW weaning Y1 (kg)	67.4 ± 1.02^{a}	63.0 ± 0.44^{b}	59.9 ± 0.45^{c}	59.7 ± 3.59^{abc}	P<0.01
LW mating Y2 (kg)	66.1 ± 0.90^{a}	63.8 ± 0.43^{ab}	61.5 ± 0.43^{c}	57.9 ± 2.49^{bc}	P<0.01
LWG weaning Y1 to mating Y2 (%)	-1.47 ± 0.85^{a}	1.76 ± 0.48^{b}	3.04 ± 0.56^{b}	-1.83 ± 5.41^{ab}	P<0.01
Number of lambs born Y2	1.65 ± 0.08^{a}	1.73 ± 0.04^{a}	1.84 ± 0.04^{a}	2.0 ± 0^{a}	P=0.06
	Number of lambs born year 2				
	0	1	2	3	
	n=20	n=164	n=380	n=59	
Total weight of lamb weaned Y1 (kg)	30.1 ± 4.63^{a}	33.6 ± 1.44^{a}	36.1 ± 0.91^{a}	38.9 ± 2.49^{a}	P=0.11
LW weaning Y1 (kg)	61.7 ± 1.40^{a}	61.9 ± 0.71^{a}	62.3 ± 0.39^{a}	63.8 ± 0.95^{a}	P=0.43
LW mating Y2 (kg)	59.2 ± 1.35^{a}	61.9 ± 0.64^{ab}	63.4 ± 0.36^{b}	66.9 ± 0.92^{c}	P<0.01
LWG weaning Y1 to mating Y2 (%)	-3.74 ± 1.88^{a}	0.55 ± 0.68^{ab}	2.16 ± 0.42^{b}	5.23 ± 1.13^{c}	P<0.01

Values within rows with different superscripts were significantly different (P<0.05)

Figure 1 Average live weight at weaning (solid line) and number of ewes (dashed line) from 2 to 11 years of age within a self-replacing flock of Wiltshire ewes during a 13 year period on one farm in Canterbury.

Figure 2 The effect of change in ewe live weight during reproduction (i.e. pregnancy and lactation) on the total weight of lambs weaned. Ewes weaning singles (circle, solid line), twins (triangle, dashed line) and triplets (square, long dashed line) are shown, ewes not rearing lambs are not shown.

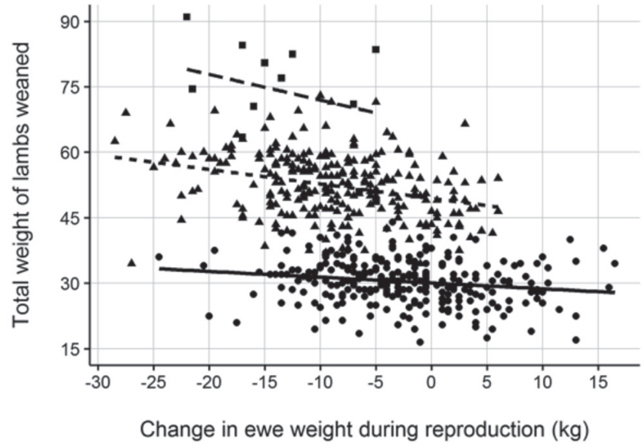


Figure 3 The effect of number of lambs weaned in the previous year (ie year 1) on the subsequent number of lambs born in year 2. (Each ewe is represented by a single dot each year, but the dots are randomly positioned around the whole number coordinates to give an appreciation of the density of animals in each category).

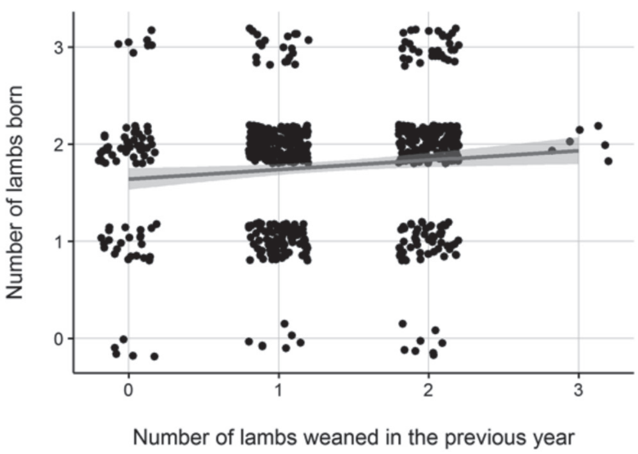
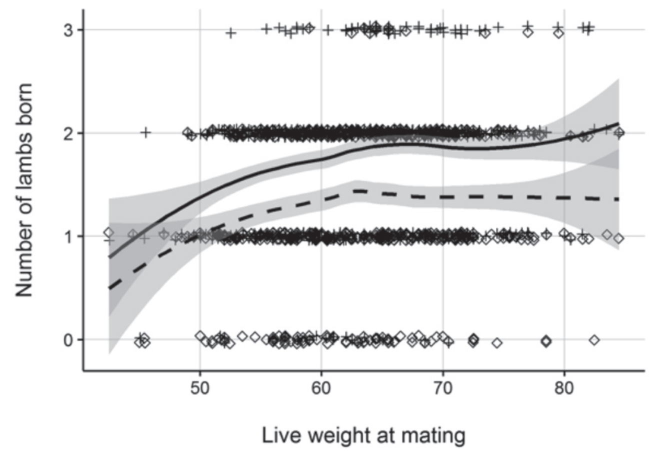


Figure 4 The number of lambs born (+) and the number of lambs weaned (diamond) from each lambing event (n = 622) according to ewe live weight at mating. The points have been randomly distributed about the whole numbers on the y-axis to show the density of points. The lines indicate the Loess smooth curve for those born (solid) and weaned (dashed), and confidence intervals for these lines.



Overall, both number of lambs born and number of lambs weaned showed a curvilinear increase with greater ewe live weight at mating until a plateau after mating weight exceeded 65 kg (Figure 4).

Discussion

Total weight of lamb weaned is a key production driver for sheep-breeding systems, providing performance can be repeated in the following year. Total weight of lamb weaned was primarily determined by the number of lambs weaned per ewe mated, a result which was expected. Nevertheless, given these ewes were all run in the same environment regardless of rearing rank it may be anticipated that, at least in part, differences in the weight of lamb weaned may also reflect the nutritional resources invested into lamb production by the ewe. Evidence for this can be seen by the negative correlation between ewe liveweight change and weight of lamb weaned shown in Figure 2, which became more pronounced with a greater number of lambs weaned. Consequently, ewe live weight at weaning may be expected to be less in ewes with a greater demand during pregnancy and lactation, which indeed was the case here (Table 1). Given the expected relationship between live weight and body condition score (van Burgel et al. 2011), these observations are in agreement with previous studies in which ewe body condition score at weaning (Mathias-Davis et al. 2011; Everett-Hincks et al. 2013) and change in body condition score during lactation (Mathias-Davis et al. 2013) were negatively correlated with the number and weight of lamb weaned. Despite this, the number of lambs weaned in year 1 showed only a tendency to influence the number of lambs born in year 2. Amer et al. (2007) reported that greater size of previous litters reduced subsequent litter size and total weight of lamb weaned from a large dataset, potentially with a range of breeds. There was no evidence to support this in the current data set, which is small in comparison and may include some aspects specific to Wiltshire sheep. In fact, with the exception of triplets for which there were relatively few records, the percentage of ewes that had twins in year 2 (56-62%) was remarkably consistent across weaning ranks in year 1, and number of lambs born in year 2 was not influenced by the weight of lamb weaned in year 1. As such, there appeared to be few carryover effects from year 1 that influenced reproductive success in year 2.

While the increase in fecundity in relation to ewe live weight was clear in lighter ewes, there was no reproductive advantage in either number of lambs born or weaned from increasing ewe live weight at mating beyond 65 kg (Figure 4). Similar observations were reported by Rutherford et al. (2003) in large- and small-framed ewes primarily of the Coopworth breed, which indicated that the maximum ovulation rate occurred at a mating weight of 67.5 kg. However, it is clear from Figure 4 that considerable variation in reproductive success remains at any given ewe live weight, and reproductive success cannot reliably be predicted from mating live weight alone. This is not surprising given frame size of individual animals can be expected to vary, which may be overcome by monitoring body condition score which is independent of animal frame size and positively associated with improved reproductive function (Kenyon et al. 2014). Although the number of lambs born in year 2 was not influenced by weight of the ewe at weaning, it is clear that the number of lambs weaned in year 1 did influence live weight at mating in year 2. As such, it is possible that under the prevailing conditions, there was insufficient opportunity for those ewes that invested greater resources into reproduction to recover prior to mating. We also suggest that closer monitoring of individual liveweight change with the use of electronic ID and preferential feeding strategies may be beneficial in ensuring ewes that have invested greater amounts of their nutritional reserves during pregnancy and lactation are sufficiently fed to ensure repeat reproductive performance in high-production systems.

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